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(54) **STRENGTHENING MEANS FOR A DIPOLE WHIP ANTENNA**

(75) Inventor: **Paul A. Bogdans**, Grand Haven, MI (US)

(73) Assignee: **R.A. Miller Industries, Inc.**, Grand Haven, MI (US)

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H01Q 9/22	(2006.01)
H01Q 9/16	(2006.01)
H01Q 1/42	(2006.01)
H01Q 21/10	(2006.01)
H01Q 1/08	(2006.01)

(52) **U.S. Cl.**

CPC ***H01Q 1/46*** (2013.01); ***H01Q 1/085*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 9/16*** (2013.01); ***H01Q 9/22*** (2013.01); ***H01Q 21/10*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/46; H01Q 9/46
USPC 343/810, 793
See application file for complete search history.

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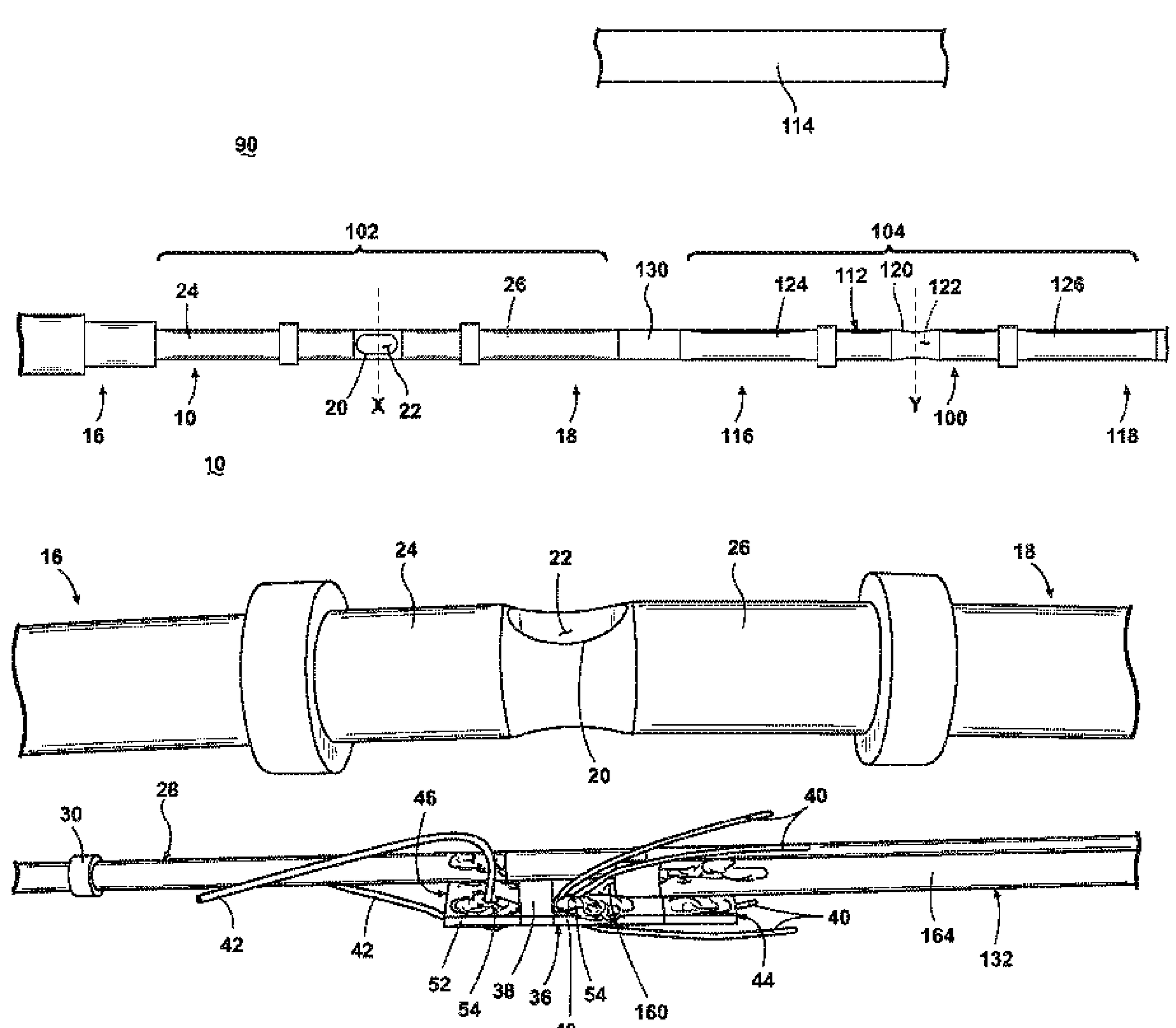
Primary Examiner — Trinh Dinh
(74) *Attorney, Agent, or Firm* — McGarry Bair PC

(57) **ABSTRACT**

A dipole antenna comprises a hollow dielectric whip, a coaxial center feed extending therethrough, and a pair of conductive dipole elements comprising an upper element and a lower element. The dipole antenna further comprises an upper element lead connecting the upper element to a first portion of the coaxial center feed at a feed point and a lower element lead connecting the lower element to a second portion of the coaxial center feed at the feed point. The dipole antenna further comprises a feed point strengthening means to mechanically strengthen the feed point against disconnection when the whip is impacted. Additionally, the dipole antenna may be a dual dipole antenna.

11 Claims, 6 Drawing Sheets



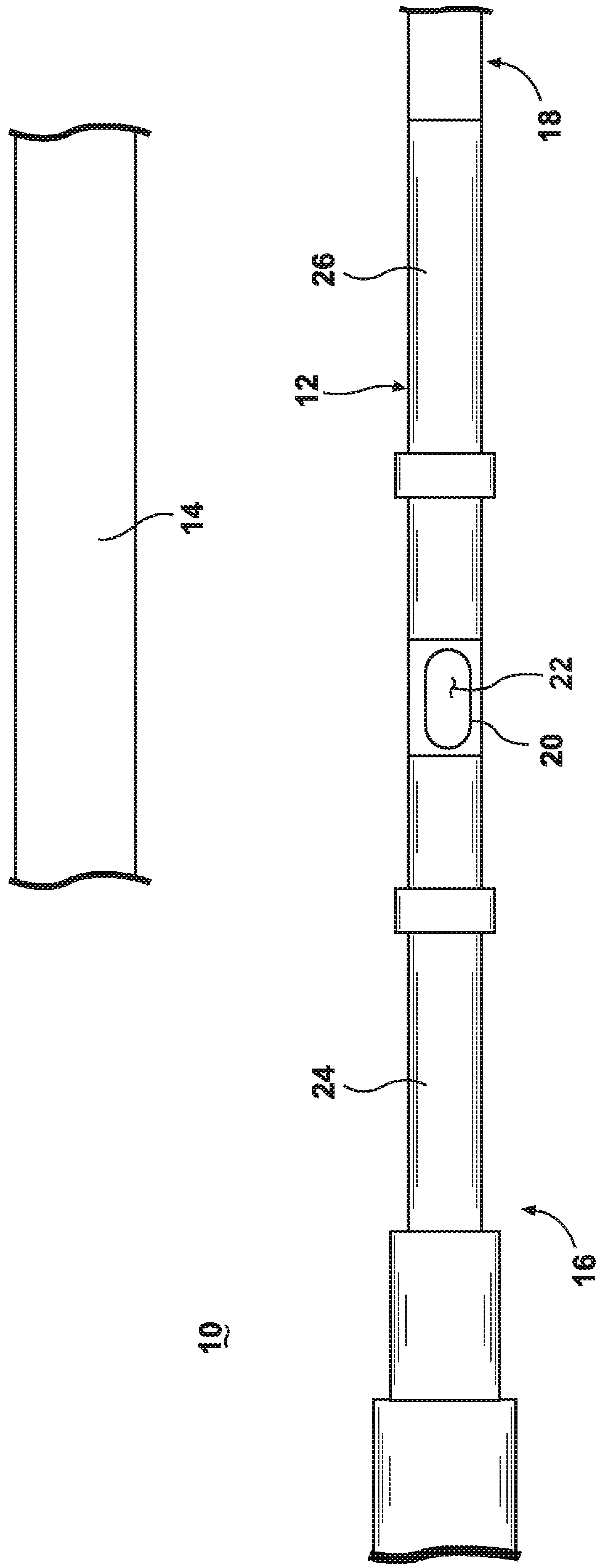


Fig. 1

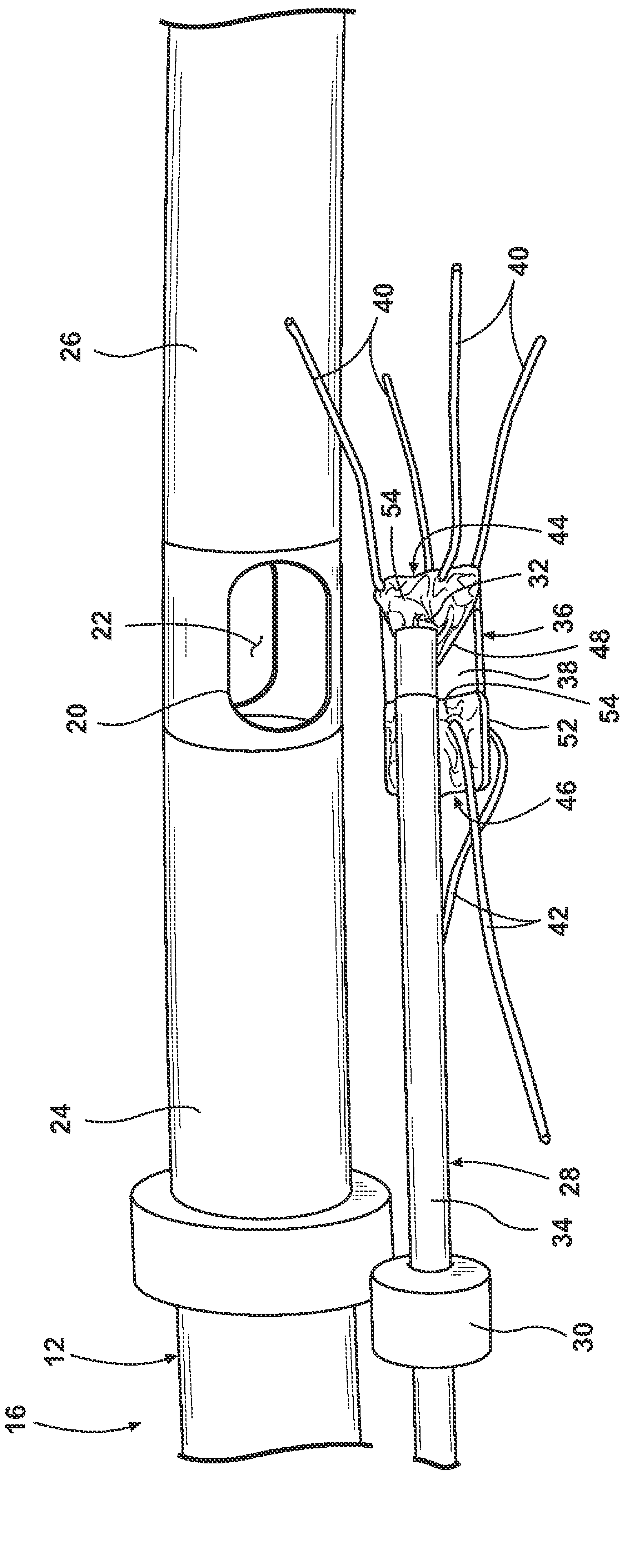


Fig. 2

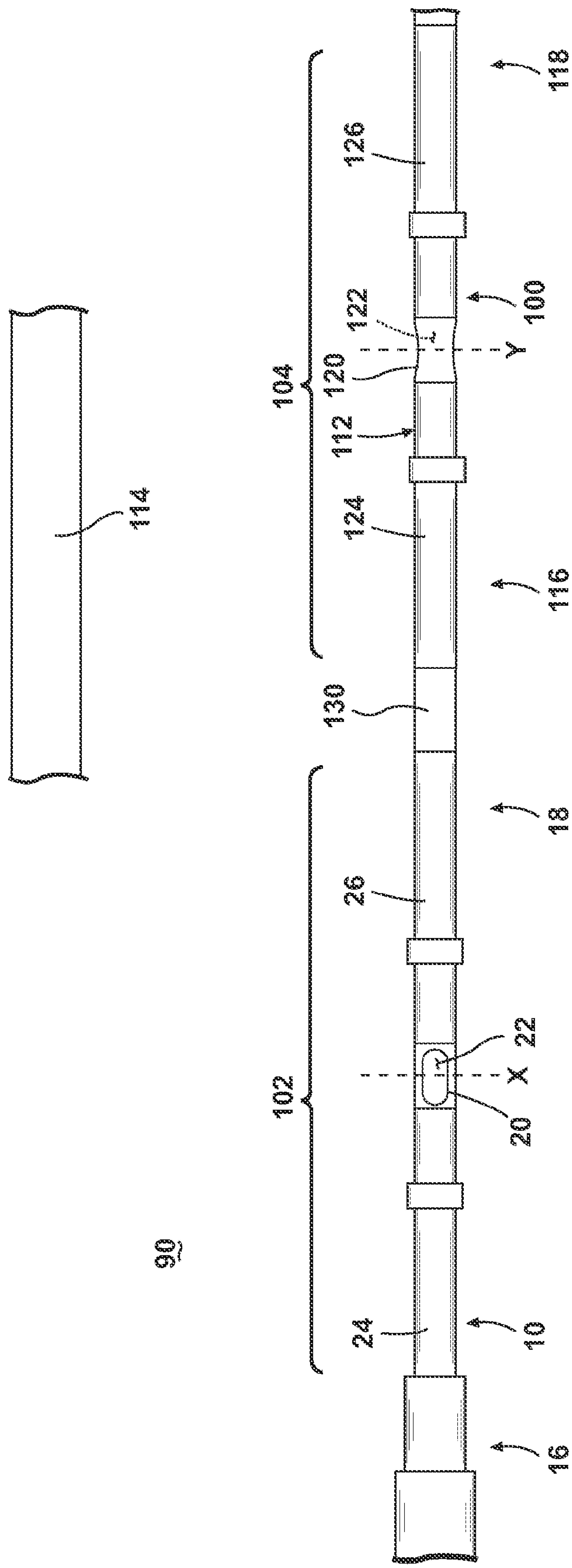

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Fig. 3

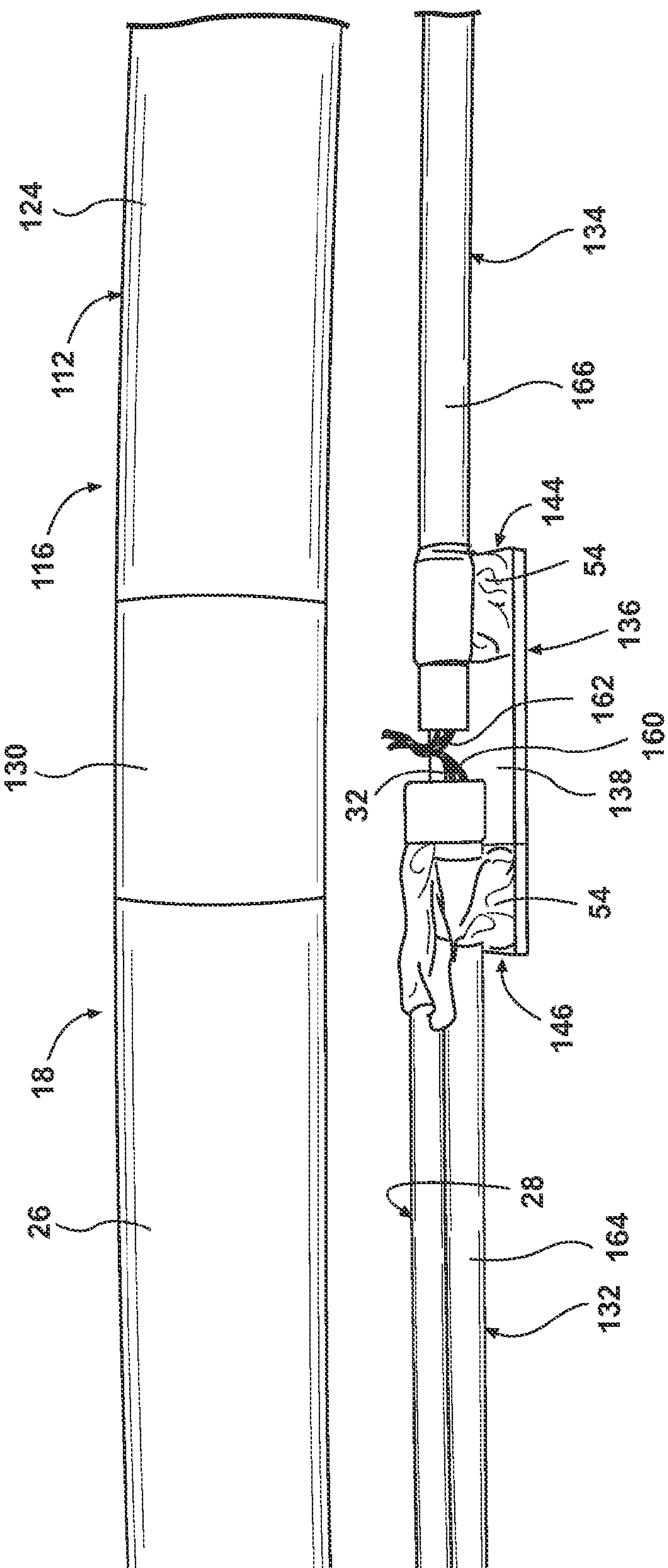
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Fig. 4

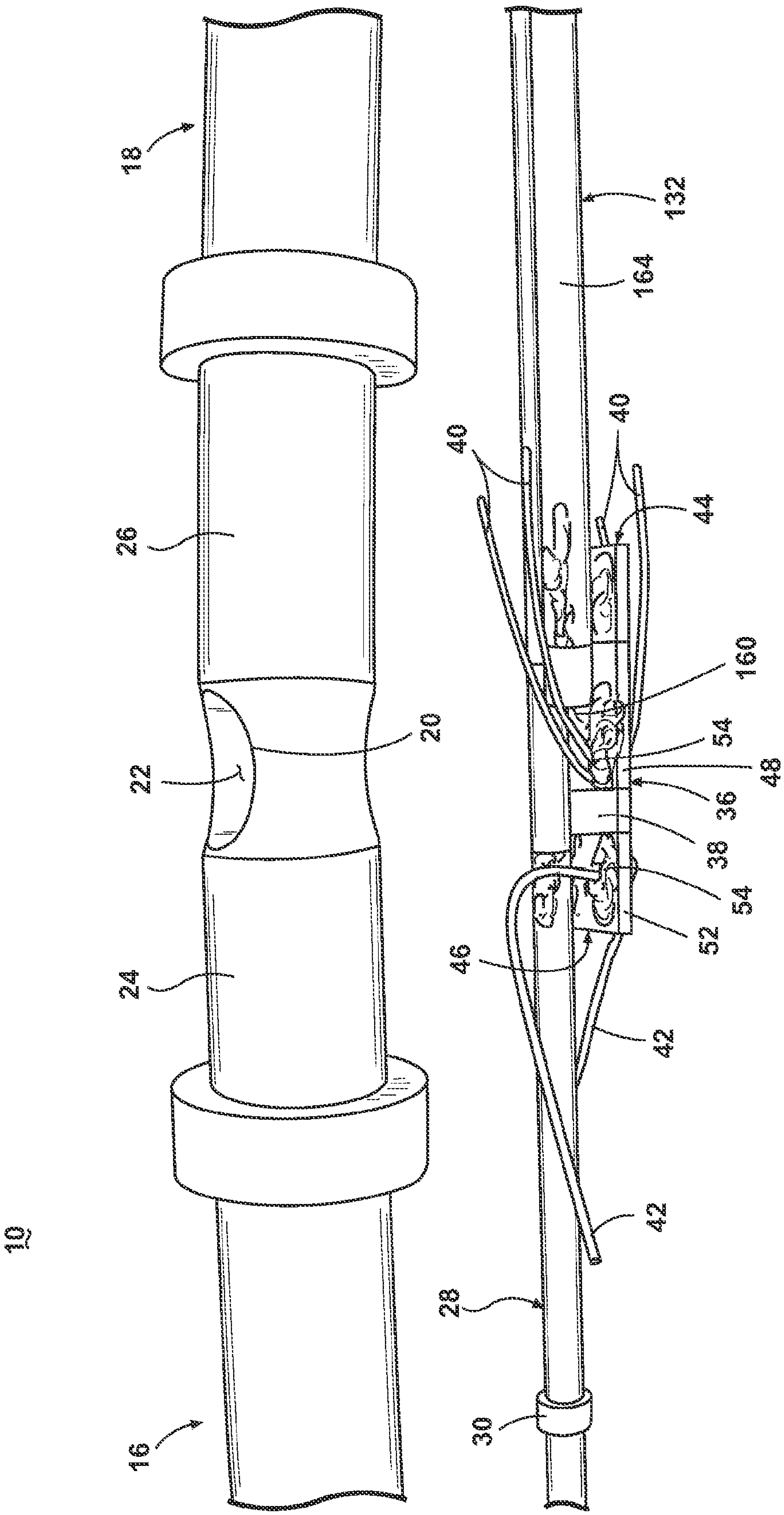
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Fig. 5

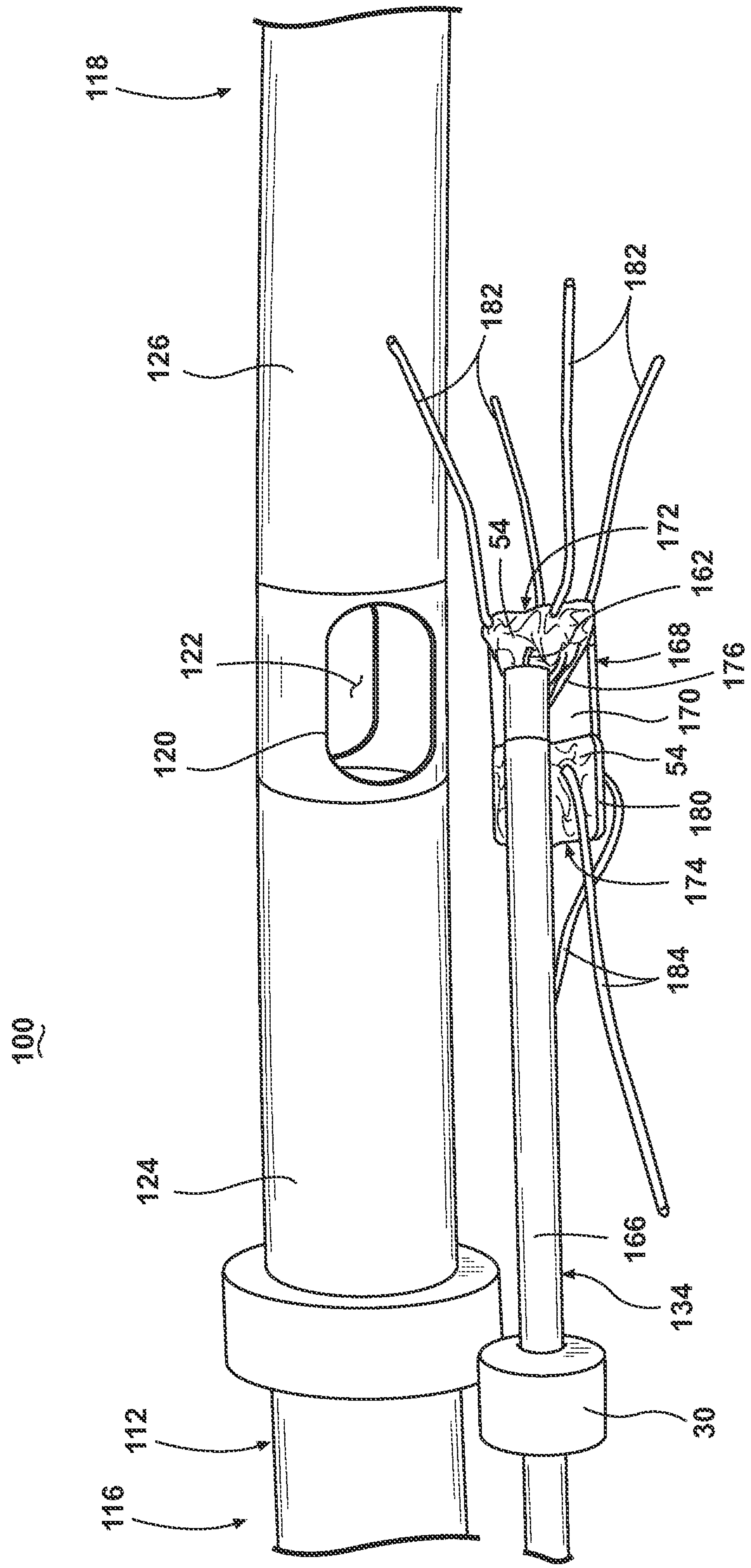
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Fig. 6

STRENGTHENING MEANS FOR A DIPOLE WHIP ANTENNA

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a National Phase application of International Application No. PCT/US2011/034767, filed May 2, 2011.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to antennas, and more specifically to a strengthening means for a dipole whip antenna.

2. Description of the Related Art

The physical size of an antenna largely depends upon the purpose for which it is to be employed. For example, an antenna for receiving a particular frequency range must have an electrical length capable of resonating within that range to achieve optimum reception. Generally, lower frequencies require longer lengths because the wavelengths at lower frequencies are longer, but limitations in use often demand design modifications to achieve appropriate electrical length in a smaller space. It is known for antennas in some applications on mobile vehicles to be 10 feet or more in length.

Most such antennas are known as "whip" antennas because they have a thin, dielectric, flexible core that carries the electrical radiator and that is mounted to a vehicle by way of a spring. These types of antennas are known as "whip" antennas because the flexible core and spring together absorb energy from forces acting on the antenna, such as impacts. A typical core will be fiberglass. If a whip antenna were to impact an object while the vehicle is in motion, the flexible dielectric core and/or the spring can absorb the force of the impact, preventing damage to the antenna or its mounting.

Some antenna applications, however, are complex, requiring multiple frequency bands and electrical lengths that make the use of thin flexible whip antennas impractical. Such antennas may require hollow dielectric cores with diameters of 1 inch or more at a length of 10 feet, and consequently are more rigid. Impacts on such antennas tend to transfer forces to components within the hollow core such as feed lines and junctions, which may become dislodged and unable to function.

SUMMARY OF THE INVENTION

According to the invention, a dipole antenna comprises a hollow dielectric whip, a coaxial center feed extending through the hollow dielectric whip, and a pair of conductive dipole elements on the hollow dielectric whip comprising an upper element and a lower element. The dipole antenna further comprises an upper element lead connecting the upper element to a first portion of the coaxial center feed at a feed point and a lower element lead connecting the lower element to a second portion of the coaxial center feed at the feed point. The feed point is disposed on an axis in a cavity in the hollow dielectric whip. According to one embodiment of the invention, the dipole antenna further comprises a feed point strengthening means to mechanically strengthen the feed point against disconnection when the whip is impacted.

In one embodiment of the invention, the feed point strengthening means comprises at least two upper element leads and at least one lower element lead. In another embodiment of the invention, the feed point strengthening means comprises a circuit board secured to the first and second portions of the coaxial center feed and the upper and lower element leads are connected to the circuit board.

In yet another embodiment, the dipole antenna further comprises a second dipole antenna on the hollow dielectric whip. The second dipole antenna comprises a second pair of conductive dipole elements comprising a second upper element and a second lower element. A second upper element lead connects the second upper element to the first portion of the coaxial center feed at a second feed point, and a second lower element lead connects the second lower element to the second portion of the coaxial center feed at the second feed point. The second feed point is disposed on a second axis in a second cavity. According to one embodiment of the invention, the feed point strengthening means comprises orienting the axes of the two cavities perpendicular to one another.

In another embodiment of the invention, the dipole antenna strengthening means comprises four upper element leads and two lower element leads at any feed point.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a perspective view of a first embodiment of a dipole antenna according to the invention.

FIG. **2** is a perspective view of a dipole of the dipole antenna of FIG. **1**.

FIG. **3** is a perspective view of a dual dipole antenna according to a second embodiment of the invention.

FIG. **4** is a perspective view of a center point and center connector of the dual dipole antenna of FIG. **3**.

FIG. **5** is a perspective view of a lower dipole of the dual dipole antenna of FIG. **3**.

FIG. **6** is a perspective view of an upper dipole of the dual dipole antenna of FIG. **3**.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to the drawings, FIGS. **1** and **2** illustrate a dipole antenna **10** according to one embodiment of the invention. The dipole antenna **10** can be included as a portion of a multiband antenna comprising a mount assembly and a whip assembly. The mount is conventional and can be affixed to a vehicle by any suitable means, typically by bolting the multiband antenna to the vehicle. The mount may contain any number of electrical connections and/or components for use with the multiband antenna and vehicle, or other structure to which it is affixed. The electrical structure of the multiband antenna is commonly known in the art, and is not germane to the invention. These portions of the multiband antenna will not be described in detail except as necessary for a complete understanding of the invention.

Dipole antenna **10** comprises a hollow dielectric whip, illustrated as a dielectric tube **12**, enclosed in a non-conductive housing **14**. The dielectric tube **12** has a lower end **16**, an upper end **18**, and at least one slot defining a feed point **20**. Feed point **20** is spaced intermediate the lower and upper ends **16**, **18** and is located within a cavity **22** formed in the hollow dielectric tube **12**. Conductive dipole elements, lower element **24** and upper element **26**, are spaced from each other on opposite sides of the feed point **20**. The conductive elements **24**, **26** can be metal foil, preferably wrapped around the dielectric tube **12**.

A coaxial center feed cable **28**, supported by at least one cable sleeve **30**, extends out of the lower end **16** through the dielectric tube **12**. The cable sleeves **30** are adapted to support one or more cables extending through the interior of the dielectric tube **12** to maintain them centered within the tube **12**. The center feed cable **28** is of the type of a commonly known coaxial cable comprising a conductive core **32** and a conductive shield **34** spaced from the conductive core **32** by a dielectric insulator. Other suitable forms of transmission lines can be used, as is commonly known in the art.

The center feed cable **28** extends to a connector **36** that is positioned at the feed point **20**, the connector **36** being positioned within the cavity **22**. The connector **36** comprises a circuit board **38**, at least two upper element leads **40**, and at least one lower element lead **42**. The circuit board **38** is of the commonly known type with various components and electrical traces disposed thereon. The circuit board **38** can be made of any known insulative material used for such applications.

The circuit board **38** comprises an upper half **44** and a lower half **46**. The upper half **44** comprises an upper conductive element **48** disposed on the circuit board **38** and a plurality of through-holes (not shown) that extend through the thickness of the circuit board **38**. The lower half **46** of the circuit board **38** is of similar construction, comprising a lower conductive element **52** disposed on the circuit board **38** and a plurality of through-holes. The through holes may be electrically conductive and may be formed concurrently by methods known in the field of circuit board manufacturing, such as by electroless plating or electroplating.

The conductive core **32** of the center feed cable **28** is connected to the upper conductive element **48** on the circuit board **38** by solder **54**, or any other known method of attaching discrete components to circuit boards. The solder **54** can be of any known type including, but not limited to, standard lead-tin (Pb—Sn) alloy or tin-silver-copper (SAC) alloy to meet stringent environmental regulations of Europe and Japan. The solder **54** may be applied to the circuit board **38** by any known method including, but not limited to, screen printing solder paste or high volume wave soldering techniques.

The plurality of upper element leads **40** are also connected by solder **54** to the upper conductive element **48** on the circuit board **38**. In one embodiment, the connector **36** comprises two upper element leads **40**. In another embodiment, the connector **36** comprises four upper element leads **40**. The upper element leads **40** may be connected to the upper conductive element **48** by individually soldering each lead **40** to the upper conductive element **48**. In another option, the upper element leads **40** may be formed of a single lead that passes through the through hole (not shown), each half of the single lead defining one upper element lead **40**. The single lead may be soldered to the upper conductive element **48** in a similar fashion. In any of these configurations, the plurality of upper element leads **40** are electrically connected to the conductive core **32** of the center feed cable **28** via upper conductive element **48**.

On the lower half **46** of the circuit board **38**, lower element lead **42** is connected by solder **54** to the lower conductive element **52**. In one embodiment, the connector **36** comprises one lower element lead **42**. In a second embodiment, the connector **36** comprises two lower element leads **42**. The lower element leads **42** may be connected to the lower conductive element **52** by individually soldering each lead **42** to the lower conductive element **52**. In another option, the lower element leads **42** may be formed of a single lead that passes through the through hole (not shown), each half of the single lead defining one lower element lead **42**. The single lead may be soldered to the lower conductive element **52** in a similar fashion. In any of these configurations, the plurality of lower element leads **42** are electrically connected to the conductive shield **34** of the center feed cable **28**, providing a ground connection for the dipole antenna **10**.

The upper element leads **40** pass out of the dielectric tube cavity **22** and are attached to the upper element **26**, thereby electrically connecting the upper element **26** to the conductive core **32** of the center feed cable **28**. The lower element lead **42** pass out of the dielectric tube cavity **22** and are attached to the lower element **24**, thereby electrically connecting the lower element **24** to the conductive shield **34** of the center feed cable **28**.

Dependent on the number included, the upper element leads **40** may be oriented in several different configurations. For example, wherein the connector **36** has two upper element leads **40**, they may be oriented substantially diametrically opposite one another other. In another example, wherein the connector **36** has four upper element leads **40**, they may be oriented and spaced evenly about the upper element **26**. Similarly, wherein the connector **36** has two lower element leads **42**, they may be oriented substantially diametrically opposite one another other.

In a second embodiment of the invention, illustrated in FIGS. **3-6**, the dipole antenna comprises the first dipole antenna **10** and a second dipole antenna **100**, together defining a coaxial dual dipole antenna **90**. The dual dipole antenna **90** comprises the first dipole antenna **10** and a dielectric tube **112** enclosed in a non-conductive housing **114**. The dielectric tube **112** has a lower portion **102** in which the first dipole antenna **10** is enclosed, and an upper portion **104** in which the second dipole antenna **100** is enclosed. The upper portion **104** comprises a lower end **116**, an upper end **118**, and at least one slot defining a second feed point **120**. Second feed point **120** is spaced intermediate the lower and upper ends **116**, **118** and is located within a second cavity **122** formed in the hollow dielectric tube **112**. Conductive dipole elements, second lower element **124** and second upper element **126**, are spaced from each other on opposite sides of the second feed point **120**. The conductive elements **124**, **126** can be metal foil, preferably wrapped around the dielectric tube **112**.

Referring to FIG. **4**, the coaxial center feed cable **28**, supported by at least one cable sleeve **30**, extends out of the lower end **16** through the dielectric tube **112**. In this second embodiment, the center feed cable **28** extends past the first connector **36** to a center connector **136** that is positioned at a center feed point **130** along the dielectric tube **112**. The center connector **136** comprises a center circuit board **138** having an upper half **144** and a lower half **146**. The center connector **136** forms a junction, both mechanical and electrical, to join the center feed cable **28** with a lower dipole lead **132** and an upper dipole lead **134**. The center feed cable **28** and lower and upper dipole leads **132**, **134** may be attached to the center circuit board **138** by any suitable mechanical means, such as soldering.

The lower and upper dipole leads **132**, **134** are electrically connected to the center feed cable **28**. Like the center feed cable **28**, the lower and upper dipole leads **132**, **134** each comprise a conductive core, lower conductive core **160** and upper conductive core **162**, respectively, and a conductive shield, lower conductive shield **164** and upper conductive shield **166**, respectively. The three conductive cores **32**, **160**, **162** are mechanically and electrically connected together and the three conductive shields **34**, **164**, **166** are mechanically and electrically connected together.

Referring to FIG. **5**, the lower dipole lead **132** extends downward from the center connector **136** to the first connector **36**. In the dual dipole antenna **90**, the first dipole antenna **10** is electrically connected to the center feed cable **28** via the lower dipole lead **132**, not directly to the center feed cable **28**, as described above for the first embodiment. The center feed cable **28** may be mechanically affixed to the circuit board **38** of the connector **36** however, to provide additional stability to the connection.

At the lower end of the lower dipole lead **132**, the lower conductive core **160** is connected to the upper conductive element **48** on the circuit board **38** of the first connector **36** by solder **54**. The remainder of the first connector **36** remains unchanged from that of the first embodiment.

Referring to FIG. **6**, the upper dipole lead **134** extends upward from the center connector **136** to a second connector **168**. The second connector **168** is much like the first connector **36**. The second connector **168** comprises a second circuit board **170** having an upper half **172** and a lower half **174**. The upper half **172** comprises an upper conductive element **176** disposed on the second circuit board **170** and a plurality of through-holes (not shown) that extend through the thickness of the second circuit board **170**. The lower half **174** of the second circuit board **170** is of similar construction, comprising a lower conductive element **180** disposed on the second circuit board **170** and a plurality of through-holes (not shown). The through holes may be electrically conductive.

The upper conductive core **162** of the upper dipole lead **134** is connected to the upper conductive element **176** on the second circuit board **170** by solder **54**, or any other known method of attaching discrete components to circuit boards. A plurality of upper element leads **182** are also connected by solder **54** to the upper conductive element **176** on the second circuit board **170**. In one embodiment, the second connector **168** comprises two upper element leads **182**. In another embodiment, the second connector **168** comprises four upper element leads **182**. The upper element leads **182** may be connected to the upper conductive element **176** by individually soldering each lead **182** to the upper conductive element **176**. In another option, the upper element leads **182** may be formed of a single lead that passes through the through hole (not shown), each half of the single lead defining one upper element lead **182**. The single lead may be soldered to the upper conductive element **176** in a similar fashion. In any of these configurations, the plurality of upper element leads **182** are electrically connected to the conductive core **32** of the center feed cable **28** via upper conductive element **176** and upper dipole lead **134**.

On the lower half **174** of the second circuit board **170**, a lower element lead **184** is connected by solder **54** to the lower conductive element **180**. In one embodiment, the connector **170** comprises one lower element lead **184**. In another embodiment, the connector **170** comprises two lower element leads **184**. The lower element leads **184** may be connected to the lower conductive element **180** by individually soldering each lead **184** to the lower conductive element **180**. In another option, the lower element leads **184** may be formed of a single lead that passes through the through hole (not shown), each half of the single lead defining one lower element lead **184**. The single lead may be soldered to the lower conductive element **180** in a similar fashion. In any of these configurations, the lower element lead(s) **184** are electrically connected to the conductive shield **34** of the center feed cable **28**, via lower conductive element **180** and the upper conductive shield **166** of upper dipole lead **134**, providing a ground connection for the second dipole antenna **100**.

The upper element leads **182** pass out of the dielectric tube second cavity **122** and are attached to the second upper element **126**, thereby indirectly electrically connecting the second upper element **126** to the conductive core **32** of the center feed cable **28**. The lower element leads **184** pass out of the dielectric tube second cavity **122** and are attached to the

second lower element **124**, thereby electrically connecting the second lower element **124** to the conductive shield **34** of the center feed cable **28**.

According to one embodiment of the invention, the ability of the antenna **10**, **90** to impact an object without sustaining damage to the antenna **10**, **90** is increased as a result of any one of the aforementioned strengthening means, taken alone or in combination. The feed point strengthening means mechanically strengthens the feed point **20**, **120** against disconnection when the whip is impacted. Referring to FIGS. **2**, **5**, and **6**, a first strengthening means comprises at least two upper element leads **40**, **182** and at least two lower element leads **42**, **184** at the feed point **20**, **120**, as described above. More preferably, the strengthening means comprises four upper element leads **40**, **182** and two lower element leads **42**, **184** at the feed point **20**, **120**. The redundant mechanical and electrical connections through the utilization of repetitive upper and lower element leads **40**, **182** and **42**, **184** provide a factor of safety in the possibility that any of the leads **40**, **182**, **42**, **184** may break or become disconnected when the antenna **10**, **90** is impacted. For example, if one pair of upper element leads **40** were to become disconnected, the second pair would maintain electrical connection between the center feed cable **28** and the upper element **26** and the antenna **10**, **90** would remain functional.

Referring to FIGS. **2**, and **4**-**6**, a second means of strengthening the antenna **10**, **90** comprises the inclusion of the circuit board **38**, **170** to mechanically and electrically connect the coaxial center feed cable **28** and the upper and lower elements **26**, **126** and **24**, **124**, as described above. The circuit board **38** provides added rigidity at the feed points **20**, **120**. This increases the connectors' **36**, **168** ability to take an impact without sustaining damage. In a similar manner, the center circuit board **138** further strengthens the center connector **136**.

A third means of strengthening the antenna **90** comprises orienting the axes of the two feed point cavities **22**, **122** perpendicular to one another. Referring to FIG. **3**, it can be seen that each cavity **22**, **122** lies along the central axis, parallel to the length of the antenna **10**, **90**. Each cavity **22**, **122** is further defined by a second axis which is perpendicular to the first axis, and which extends along the opening of the cavity **22**, **122**. The second axis of cavity **22** is referred to in the figures as X, and the second axis of cavity **122** is referred to as Y. To increase the rigidity of the antenna **90**, the axes X and Y are oriented perpendicular to one another. This relative orientation increases the antenna's resistance to bending and deflection in a given direction.

As previously stated, these strengthening means can be included on the antenna **10**, **90** either individually, or in various combinations with one another. It should be obvious that the third strengthening means cannot be implemented on the antenna **10** because antenna **10** only comprises one cavity **22**, however.

While the invention has been specifically described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not of limitation. Reasonable variation and modification are possible within the scope of the forgoing disclosure and drawings without departing from the spirit of the invention which is defined in the appended claims.

What is claimed is:

1. A dipole antenna comprising:

a hollow dielectric whip,

a coaxial center feed extending through the hollow dielectric whip,

- a first pair of conductive dipole elements on the hollow dielectric whip comprising a first upper element and a first lower element,
- a first upper element lead connecting the first upper element to a first portion of the coaxial center feed at the at least one first feed point,
- a first lower element lead connecting the first lower element to a second portion of the coaxial center feed at the at least one first feed point, wherein the at least one first feed point is disposed on a first axis of a first cavity in the hollow dielectric whip,
- a second pair of conductive dipole elements comprising a second upper element and a second lower element,
- a second upper element lead connecting the second upper element to the first portion of the coaxial center feed at a second feed point, and
- a second lower element lead connecting the second lower element to the second portion of the coaxial center feed at the second feed point, wherein the second feed point is disposed on a second axis of a second cavity,
- wherein the first cavity and second cavity each has a central axis parallel to the length of the hollow dielectric whip, and the first and second axes are oriented perpendicular to one another.

2. A dipole antenna according to claim **1** comprising at least two upper element leads and at least one lower element lead.

3. A dipole antenna according to claim **2** wherein the strengthening means comprises four upper element leads and two lower element leads at any feed point.

4. A dipole antenna according to claim **2** wherein any two upper element leads are oriented substantially diametrically opposite each other, and any two lower element leads are oriented substantially diametrically opposite each other.

5. A dipole antenna according to claim **1** comprising a circuit board secured to the first and second portions of the coaxial center feed and the first upper and first lower element leads connected to the circuit board.

6. A dipole antenna according to claim **1** wherein the first and second pairs of conductive dipole elements are coaxial.

7. A dipole antenna according to claim **1** wherein the first and second pairs of conductive dipole elements are connected to the first portion of the coaxial center feed at a center feed point.

8. A dipole antenna according to claim **1** comprising four element leads and two lower element leads at any feed point.

9. A dipole antenna according to claim **8** wherein the four upper element leads are oriented and spaced evenly about any of the first and second upper elements.

10. A dipole antenna according to claim **1** wherein the two upper element leads are oriented substantially diametrically opposite each other, and the two lower element leads are oriented substantially diametrically opposite each other.

11. A dipole antenna according to claim **1** wherein the first portion is a conductive core and the second portion is a conductive shield spaced from the conductive core by a dielectric insulator.

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